THE WEATHER AND CIRCULATION OF NOVEMBER 1955 [1]

A Month with Pronounced Blocking and Extreme Cold

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1. INTRODUCTION

November of 1955 was unusually cold and stormy over most of the United States. Severe winter weather gripped the Northwest in particular, with blizzards bringing record-breaking cold and snow. This unusual weather was associated with a pronounced blocking regime which carried over from October [1] and indeed has been typical of this year as a whole [2].

2. TEMPERATURE DISTRIBUTION

Except for some of the Mexican Border States, unseasonably cold weather was the rule throughout the country. Repeated outbreaks of intensely cold Canadian air invaded the northern United States, and several of these were strong enough to overspread the entire nation. In the Northwest these frigid surges were sufficient to produce new record low temperatures for the month for many stations. To illustrate the extreme nature of this November's cold weather, table 1 was prepared.

For Spokane, Wash., and Billings, Mont., these figures represent new extremes of cold for the period during which records have been maintained. For most of the other stations one must go all the way back to 1896 [2] to find a colder November.

To illustrate further the extent and severity of this year's cold snap, figure 1 has been prepared to show the standardized departure from normal for the monthly mean temperature of November 1955 (Chart I). The data were compiled by dividing the observed departure from normal of this month's mean temperature by that station's standard deviation for November computed for the 30-year period 1921 through 1950 [3]. The extreme departure of −15.8° F. at Great Falls, Mont., is 3.4 standard deviations lower than the November normal. Noteworthy is the fact that Tatoosh Island, Wash., though its mean temperature was only 6.1° F. below normal, shows a standardized departure from normal almost equal to that at Great Falls. In this sense the November aberration at Tatoosh was comparable in severity and unusualness to that at Great Falls owing to much smaller variability along the coast than inland.

In considering the magnitude of this month's temperature abnormality, it may be of interest to consider probabilities of occurrence. Under the assumption of a random sample from a normally distributed population and without serial correlation from one year to the next, a standardized departure of −2.5 has a chance of occurrence of roughly one in a hundred. Thus an inspection of figure 1 reveals that over a strip covering northern Washington and Idaho, most of Montana and the Dakotas,

TABLE 1.—*Monthly mean temperature (° F.) for November 1955 at selected stations arranged in order of decreasing standardized departure from normal*

Station	Mean	Departure from normal	Standardized departure from normal	Previous minimum	
				Mean	Year
Great Falls, Mont	19.4	−15.8	−3.4	14.8	1896
Tatoosh Island, Wash	41.3	−6.1	−3.2	39.7	1896
Havre, Mont	13.7	−17.2	−3.1	3.8	1896
Miles City, Mont	19.0	−14.0	−2.8	12.7	1896
Bismarck, N. Dak	15.1	−13.3	−2.8	7.2	1896
Valentine, Nebr	26.0	−9.3	−2.7	19.2	1896
Helena, Mont	19.7	−12.0	−2.7	18.3	1896
Huron, S. Dak	22.5	−10.0	−2.6	13.6	1896
North Platte, Nebr	29.3	−7.5	−2.6	28.2	1919
Rapid City, S. Dak	24.8	−10.5	−2.6	20.9	1896
Billings, Mont	*24.1	−11.7	−2.5	26.6	1897
Seattle, Wash	41.3	−5.7	−2.5	38.6	1896
Spokane, Wash	*28.1	−7.6	−2.5	30.6	1896

*New record.

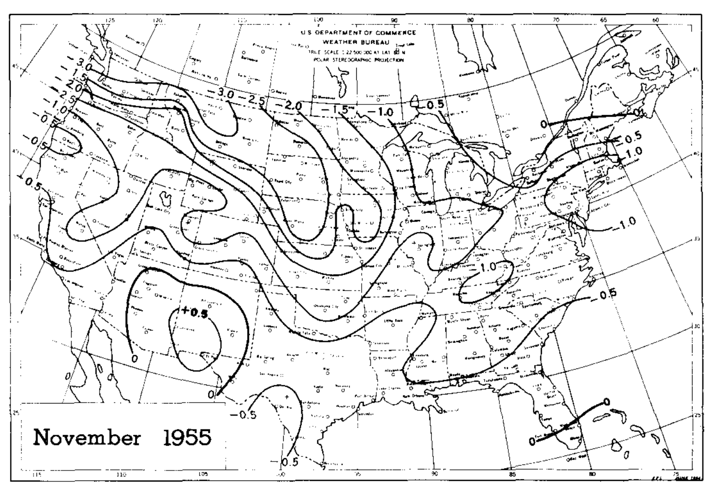

FIGURE 1.—Standardized departures from normal of monthly mean temperatures for November 1955. Average temperatures along the Canadian border of the northwestern States were more than 3 standard deviations below normal.

[1] See Charts I–XV following p. 291 for analyzed climatological data for the month.

[2] For an interesting account of the extreme weather of that unusual November, see *Monthly Weather Review*, vol. 24, No. 11, November 1896.

and northern Nebraska, a November as severe as this one has an extremely low probability of occurring by chance.

The new records of minimum temperatures for the month which resulted from the intense polar outbreaks were even more spectacular. At Helena, Mont., for example, the temperature dropped to a minimum of −29° F. on November 15, a full 7° below the previous November extreme of −22° set in 1896. Similarly, Salt Lake City suffered a minimum of −14° on the 16th as compared with a previous November low of 0° in 1931, and Missoula, Mont. recorded −23° on the 16th as compared to −11° in 1919. Some other new minimum temperature records for November are: Kalispell, Mont., −14°; Rapid City, S. Dak., −14°; Lewiston, Idaho, −3°; and Tatoosh Island, Wash., 19°. In addition, numerous previous records for minimum temperatures on individual days were broken at most stations throughout the Northwest. For comparison a few of these are listed in table 2.

TABLE 2.—*New records of daily minimum temperature (° F.) set during November 1955*

	Minimum	Date
Havre, Mont	−26	17
Great Falls, Mont	−23	13
Glasgow, Mont	−21	13
Billings, Mont	−14	14
Pocatello, Idaho	−13	16
Casper, Wyo	−12	15
Winnemucca, Nev	−5	15
Denver, Colo	−4	15
Seattle, Wash	13	15

Most of these records followed an intense storm of near-blizzard proportions which developed over the Great Basin and remained nearly stationary for several days. In addition to the extreme cold, the situation was further aggravated by heavy drifting snow. (For further details on this storm see article by O'Connor in this issue.)

One other record-breaking aspect of this cold spell was its duration. The report from Helena, Mont., that temperatures remained at subzero levels over a snow covered surface for 138 consecutive hours from the 11th to the 17th (longest such period on record) was typical of reports from most other stations in that area. New record daily minima were set each day from the 11th through the 17th at Seattle and from the 14th through the 17th at Salt Lake City. Similar statements could be made of most other stations in the northwest quarter of the country.

Figure 2 presents a broader view of the temperature distribution during this period. Of interest is the sharp south-to-north temperature anomaly gradient in the central part of the country. Thus, at the same time record minima were being set in the Northwest new record high temperatures occurred on the 16th at Charlotte, N. C. (82° F.) and St. Louis, Mo. (81°).

Of some interest is the fact that much milder weather prevailed over the northern Rockies during the previous month [1], so that November's intense cold constituted a

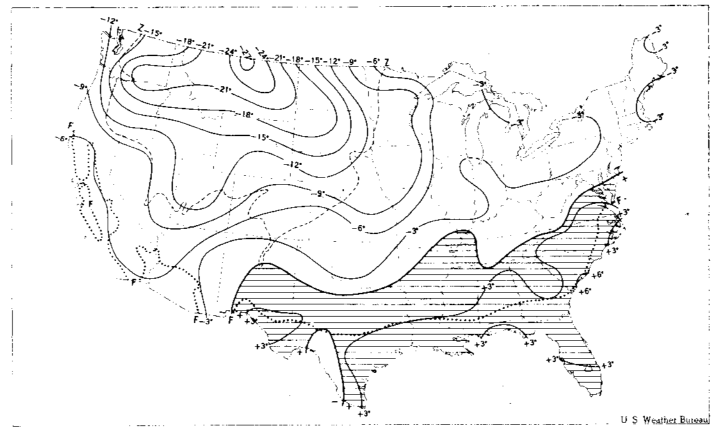

FIGURE 2.—Departure of average temperature from normal for the week ending at midnight, l. s. t., November 20, 1955. Shaded areas are normal or above. Dotted line indicates southern limit of freezing temperatures, dashed line, southern limit of 0° F. Note extremely cold weather in the Northwest and contrasting warmth in the Southeast. (From *Weekly Weather and Crop Bulletin, National Summary*, vol. XLII, No. 41, Nov. 21, 1955.)

sharp reversal from October. This tendency is in line with the findings of Namias [4] and has been discussed by several writers of previous November articles of this series [5, 6, 7, 8]. In this particular November, however, the tendency for reversal was characteristic only of the northern half of the country, whereas the southern half, and particularly the Southeast, saw the anomaly regime of October persist into this month.

3. TEMPERATURE AND CIRCULATION

There are several interesting aspects of the interrelationship between the observed temperature anomaly and the associated circulation pattern. While the blocking regime will be treated further in section 5, it is appropriately mentioned at this point since, as usual, it exerted a major controlling influence over the circulation pattern and served to displace the westerlies and associated cold air well south of normal.

However, aside from this general observation, it is not immediately apparent from examination of figure 3 why the cold wave should have been so intense. In fact, objective estimates based on this figure would not call for the cold to be as extensive or severe. One reason for this discrepancy is to be found in the fact that the Canadian source region for the Pc air was considerably colder than normal. Figure 4 depicts the observed distribution of thickness anomaly from surface to 700 mb. for the month. It is evident that the area of extreme cold was not confined to the northwestern United States but covered the whole extent of the Canadian Rockies. Thus, the Canadian air which repeatedly swept into the United States during the month was abnormally cold at its source, and therefore temperatures over the United States were appreciably lower than would be expected from the observed circulation alone. It is also pertinent that the center of anomalously cold air could be traced steadily southeast-

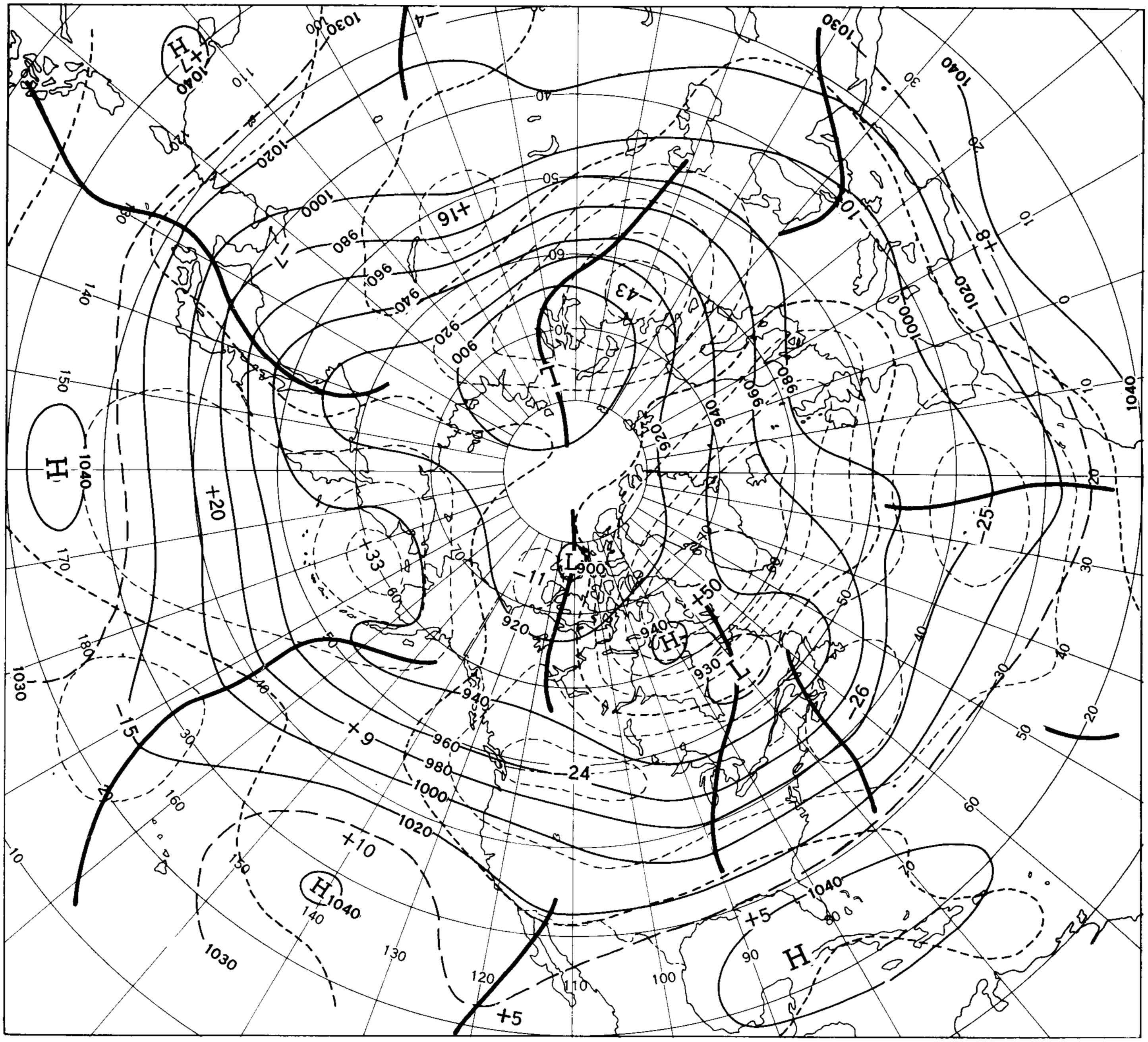

FIGURE 3.—Mean 700-mb. height contours and departures from normal (both in tens of feet) for November 1–30, 1955. Blocking was prevalent over the Davis Strait and Bering Sea, as evidenced by large centers of positive anomaly in those regions. As a result the westerlies were shifted south of normal, but with speeds greater than normal.

ward from the Arctic coast of Alaska on the mid-October—mid-November monthly mean chart to northern Montana on the mid-November—mid-December chart. This suggests that anomalous northwesterly flow over Alaska (fig. 3) was instrumental in pouring cold Arctic air into northwestern Canada. The marked effect of abnormally cold air in northwestern Canada upon temperatures in the United States has been discussed in several previous articles [5, 9, 10].

4. OTHER ASPECTS OF THE GENERAL CIRCULATION

As is readily apparent from figure 5, the 700-mb. zonal index as averaged from 5-day mean maps remained well below normal for the entire month of November, but with a general trend toward recovery from the very low value which climaxed the violent fluctuations of October described by Dunn [1]. In fact, the zonal index of 5.0 computed from the 5-day mean map of October 29–November 2 is the next lowest value observed in October or November (lowest 3.3, Nov. 25–29, 1950) in the 12 years these figures have been calculated.

The magnitude of this aberration for the hemisphere as a whole is well depicted by figure 6 which compares the mean sea level pressure profile with the normal profile for the month. Noteworthy is the very large excess of mass north of 50° N. and the compensating deficit farther south.

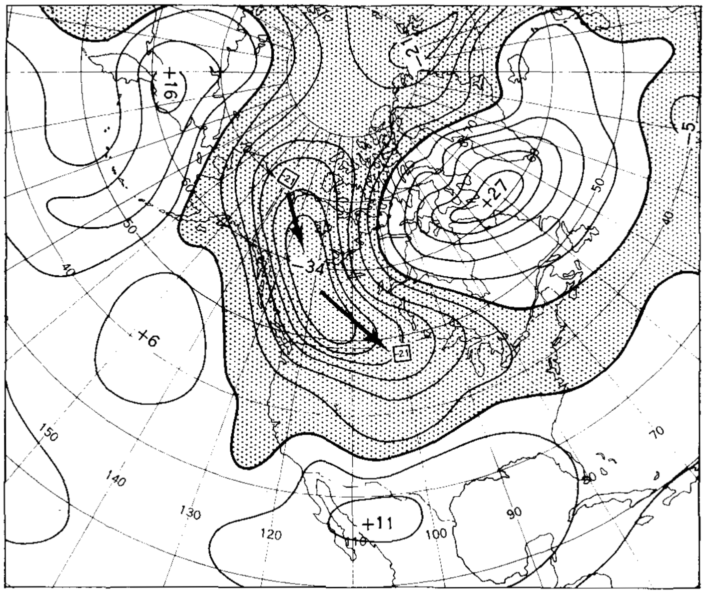

FIGURE 4.—Mean departure from normal of thickness (700 mb.-1,000 mb.) for November 1–30, 1955, analyzed for intervals of 50 ft. with centers labeled in tens of feet. Below normal thickness (shaded) covered most of the United States, with center of −340 ft. corresponding to a mean virtual temperature of about 11° C. below normal. Note warmth of blocking High over northeastern Canada and over Bering Sea with centers 9° C. (270 ft.) and 5° C. (160 ft.) respectively, above normal.

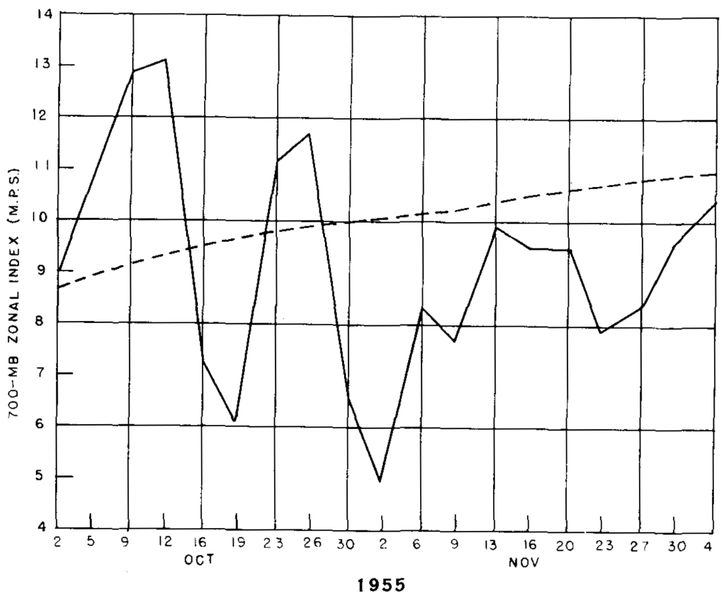

FIGURE 5.—March of 5-day mean zonal index at 700-mb. for the Western Hemisphere in the latitude belt 35°–55° N. during October and November 1955, with normal index dashed. Note that, following the very low value of 5.0 m. p. s. for the period October 29–November 2, the index remained below normal for the entire month.

An additional diagram typical of the low index state is the zonal wind speed profile shown in figure 7. It is evident that the latitude of strongest wind was displaced equatorward, with a secondary maximum appearing in polar regions and below normal speeds from 45° N. northward to about 65° N.

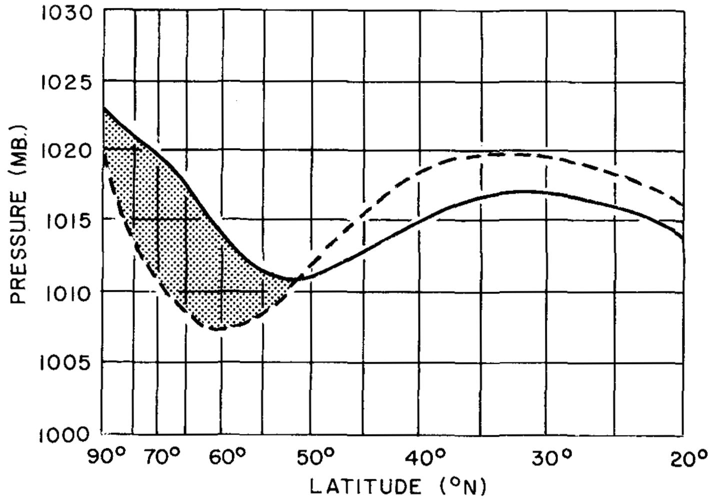

FIGURE 6.—Mean sea level pressure profile in the Western Hemisphere for November 1955 with normal profile dashed. Excess of pressure in northerly latitudes was offset by deficit to the south.

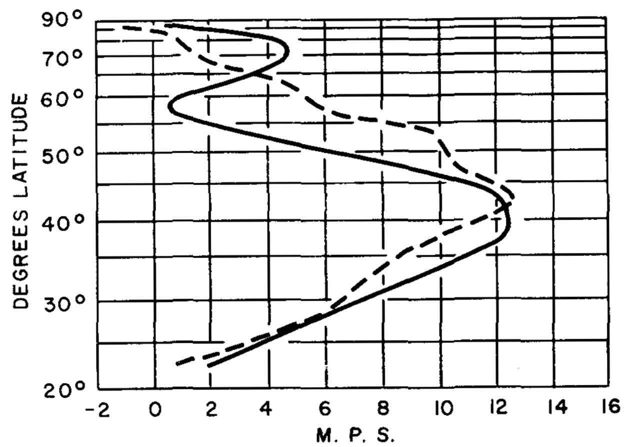

FIGURE 7.—Mean 700-mb. zonal wind speed profile in the Western Hemisphere for November 1955, with normal profile dashed and area of positive anomaly shaded. The west wind maximum was stronger and farther south than normal. Note tendency for secondary jet in polar latitudes.

A similar distribution was evident at 200 mb. (fig. 8), where a remarkable belt of subnormal winds extended throughout the Western Hemisphere roughly paralleling 55° N. The jet stream, on the other hand, was well to the south over the Atlantic with its axis extending from Hatteras to West Africa. Over the Pacific, however, the principal jet stream was farther north and corresponded more closely to its usual latitude, but with a secondary jet just north of the Hawaiian Islands.

5. THE BLOCKING

ATLANTIC

The circulation features described above resulted from pronounced blocking which was influential in controlling the Western Hemisphere circulation for October [1] and continued strongly through November. The most conspicuous center of blocking was located in the Davis Strait (fig. 3) where 700-mb. heights as much as 500 ft.

above normal were observed. The belt of above normal heights associated with this center covered a large region from northeastern Canada across the northern Atlantic to Europe. As a result of this block not one storm proceeded along the usual track across the North Atlantic to Iceland. There was considerable stalling and looping of centers along the Atlantic Seaboard as Lows were forced northward or northeastward to dissipate in the Davis Strait. Since 700-mb. heights were markedly below normal along the northern border but above normal to the south, the westerlies, though shifted southward, were faster than normal over the United States and particularly over the Southeast (fig. 3).

An inspection of 5-day mean 700-mb. height departure from normal charts reveals that two strong blocking surges proceeded westward from Europe to make up the anomaly center over the Davis Strait. The first surge came out of Europe in late October and became entrenched in Davis Strait with a maximum intensity of +1,000 ft. on the mean map for October 29–November 2. It contributed to the minimum index for that period shown on figure 5. This general locale remained the seat of rather pronounced blocking during the first half of the month. The blocking weakened around the third week of the month, only to be replaced thereafter by a second strong surge from the Atlantic. In this case maximum intensity of +940 ft. was reached in the northeastern Atlantic on the mean map for November 19–23. This block worked its way westward to exert a strong influence on northeastern Canada by the end of the month.

The broad band of above normal 700-mb. heights in the North Atlantic was associated with a belt of subnormal heights to its south. The two separate centers of negative anomaly in figure 3 reflect the variation in the blocking regime from the first half month to the last. During the former period, when the blocking was principally active over the Davis Strait, an intense, extensive, and persistent cyclone developed in the eastern Atlantic. In the latter half month, on the other hand, with blocking mainly concentrated in the northeastern Atlantic, a similar broad intense Low developed southeast of Newfoundland. Sixty-foot waves and 82-m. p. h. winds associated with the peak intensity of this storm resulted in considerable damage to the "Texas tower" radar "island" under construction off New England.

PACIFIC

Blocking was also active in the Pacific sector as evidenced by the mean ridge in the Bering Sea, which replaced the mean Low normally found in that area. This block was not as extensive nor as strong as its Atlantic counterpart, but it did achieve a positive anomaly value of 330 ft. for the month (fig. 3). Furthermore it was not as effective in producing negative anomalies to its immediate south as was the case with the stronger Davis Strait cell. In fact, above normal heights prevailed over the bulk of the Pacific, with only one center of negative anomaly showing on the mean 700-mb. chart for the month, and that was well to the south in tropical latitudes just northwest of the Hawaiian Islands. The blocking was instrumental, however, in deflecting several storms from their more usual course across the northeastern Pacific (Chart X). Some of these plunged into the western United States (fig. 9) and subjected that area to the cold stormy weather previously described.

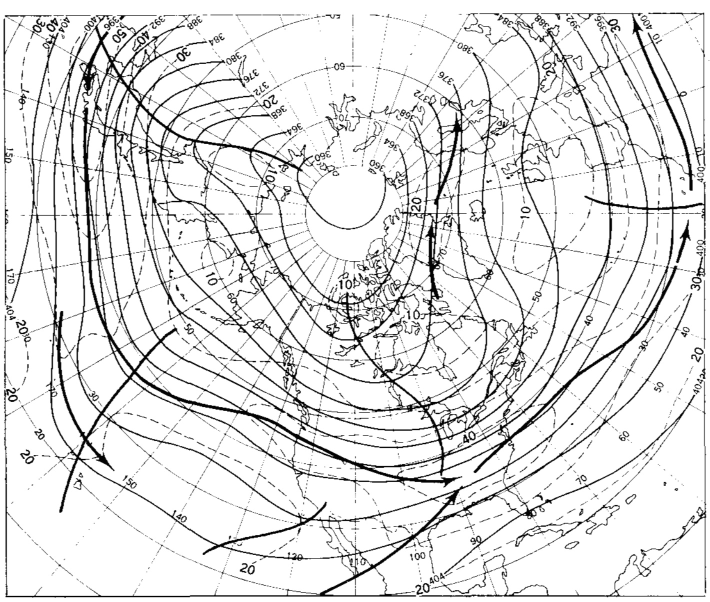

FIGURE 8.—Mean 200-mb. contours (in hundreds of feet) and isotachs (in meters per second) for November 1–30, 1955. Solid arrows indicate the position of the mean 200-mb. jet stream. Note the broad band of slow speeds along 55° N. and the weak secondary jet near the Hawaiian Islands.

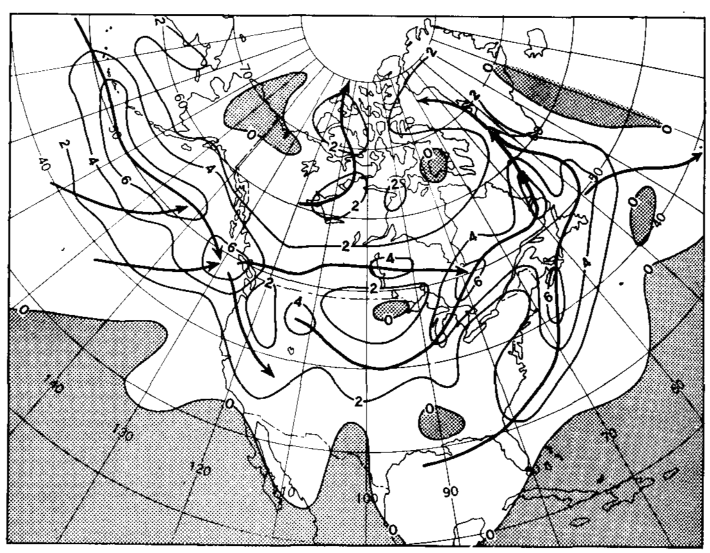

FIGURE 9.—Frequency of cyclone passages (within 5° squares at 45° N.) during November 1955. Note tendency of storms to plunge into the western United States and the complete absence of tracks across the northeastern Atlantic.

One interesting aspect of the history of the Pacific cell is the fact that it reached its greatest intensity over the Bering Sea (880 ft. in excess of normal) during the period October 29–November 2; simultaneously with the maximum intensity of the Davis Strait anomaly. It was this combination of two intense blocking cells which resulted in the near-record low value for the 700-mb. zonal index previously noted.

The Pacific anomaly was also composed of two marked surges. The first, mentioned above, slowly retreated to northeastern Siberia. It was in turn replaced by a vigorous new center which reached a peak intensity of +750 ft. above normal in the eastern Aleutians on the mean map for November 9–13. It was the strong ridge in the Gulf of Alaska associated with this anomaly which was responsible for deploying the intensely cold air from the Canadian Rockies into the western United States. It maintained strongly over the east-central Pacific and Aleutians during the latter half month and finally retrograded into the Bering Sea and weakened.

6. PRECIPITATION

As might be expected with many storm tracks displaced from Canada into the United States by the low index circulation, precipitation over much of the country exceeded normal (Chart III). The principal exception was a large area of rain shadow over the central and southern Plains States. This was the second month of deficient moisture in that area and the dry weather coupled with the unseasonable cold caused soil to become dry and loose and susceptible to wind damage.

In direct contrast, the northern and western States received copious precipitation. Except for the Pacific coast, this occurred mainly as snow and many localities in the northern Border States west of the Great Lakes reported snow amounts of near record proportions (Charts IV and V). These heavy deposits appear to have been mainly a consequence of proximity to the principal storm tracks and overrunning of the cP air by moist Pacific air masses. Extensive snow cover may have contributed to unusual cold in the Northwest. An added orographic effect along the coasts of Washington and Oregon produced very heavy precipitation in that area as a result of the strong westerlies blowing perpendicular to the mountains.

Most of the East experienced some precipitation with amounts generally above normal. The largest totals were reported from the Ohio Valley and in New England. The former fell mainly as heavy snows, while the New England rains were associated mostly with a small but intense storm which occurred November 4–6 and produced minor flooding in an area not yet recuperated from the devastating floods of August and October. This storm has been briefly described by Kangieser [11]. In the Southeast, Gulf moisture produced spotty but generally adequate precipitation.

7. KONA STORMS IN THE HAWAIIAN ISLANDS

It has been previously pointed out that the only negative 700-mb. height anomaly in the whole of the Pacific was the rather sizeable one of 150 ft. to the northwest of the Hawaiian Islands. It should be remarked that the associated trough was well defined on the monthly mean maps for 700 mb. (fig. 3) and 200 mb. (fig. 8). This trough was remarkably persistent and was located in about the same position on each individual 5-day mean map throughout the month of November, and on each seasonal mean map during the past year [2]. This anomaly was associated with Kona rains in the western Islands which were generally heavy and in some instances record breaking. At Kileaua Plantation, for example, on the north coast of the Island of Kauai, the total rainfall for November stood at 29.09 inches, a 30-year record. The bulk of this rain, 22 inches of it, fell in a 16-hour period over the weekend of the 12th–13th in a particularly intense Kona storm of the type described by Gulick [12]. The resulting flood damage to plantations and truck farms was estimated at over $100,000. It is of interest to note that the departure from normal pattern in the Pacific (fig. 3) resembles that described by Solot [13] as being ideal for producing heavy rain in Kauai.

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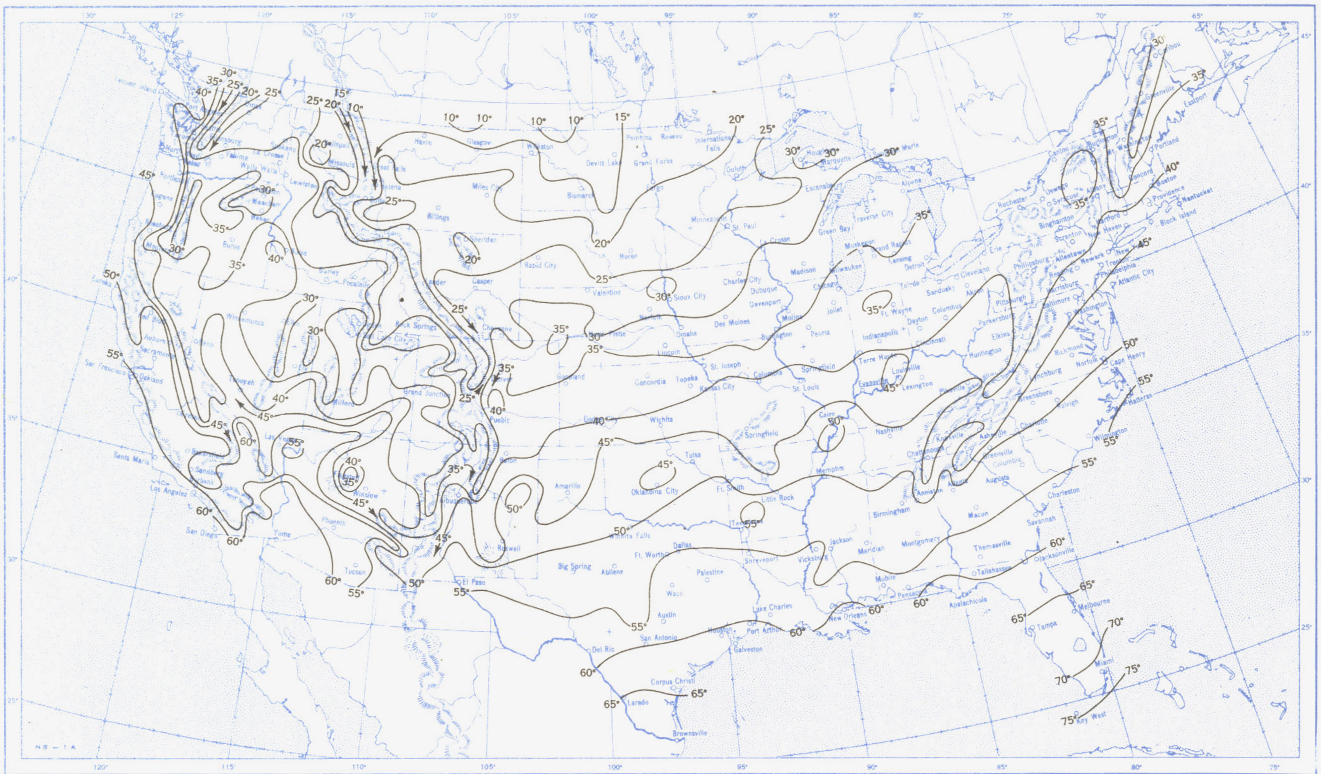
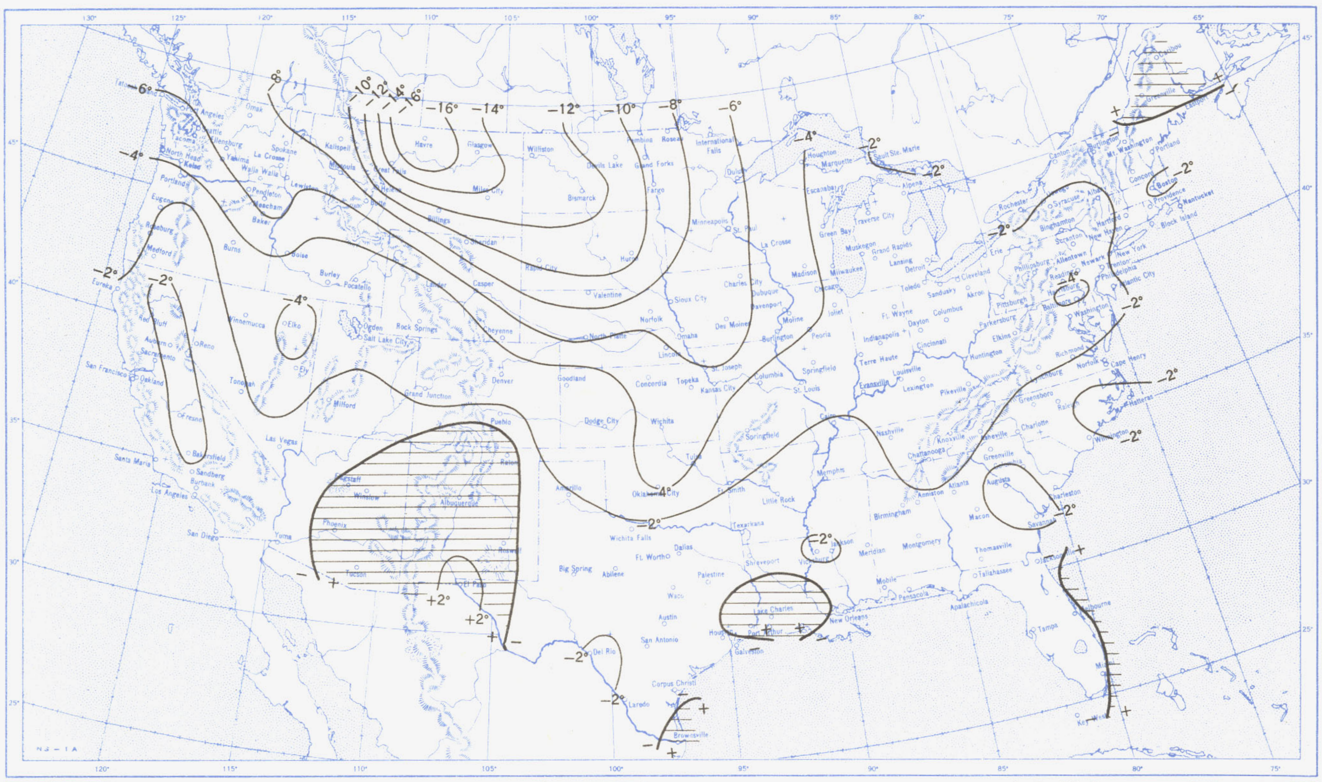
CORRECTION

MONTHLY WEATHER REVIEW, vol. 83, No. 10, p. 222: In legend to figure 9 the last sentence should read, "The N-NE-E wind group *raises* the level of the sea; the SW-W-NW group *lowers* it."

Chart I. A. Average Temperature (°F.) at Surface, November 1955.



B. Departure of Average Temperature from Normal (°F.), November 1955.

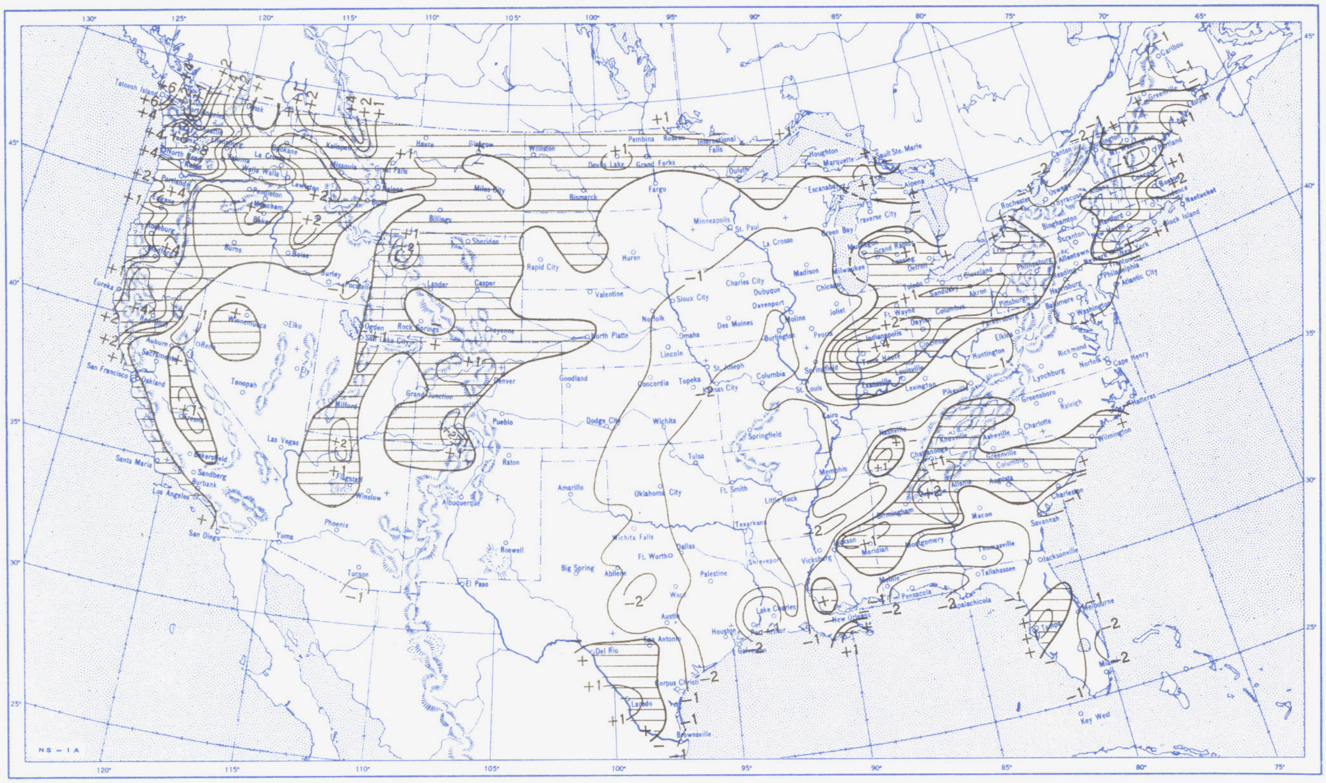


A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

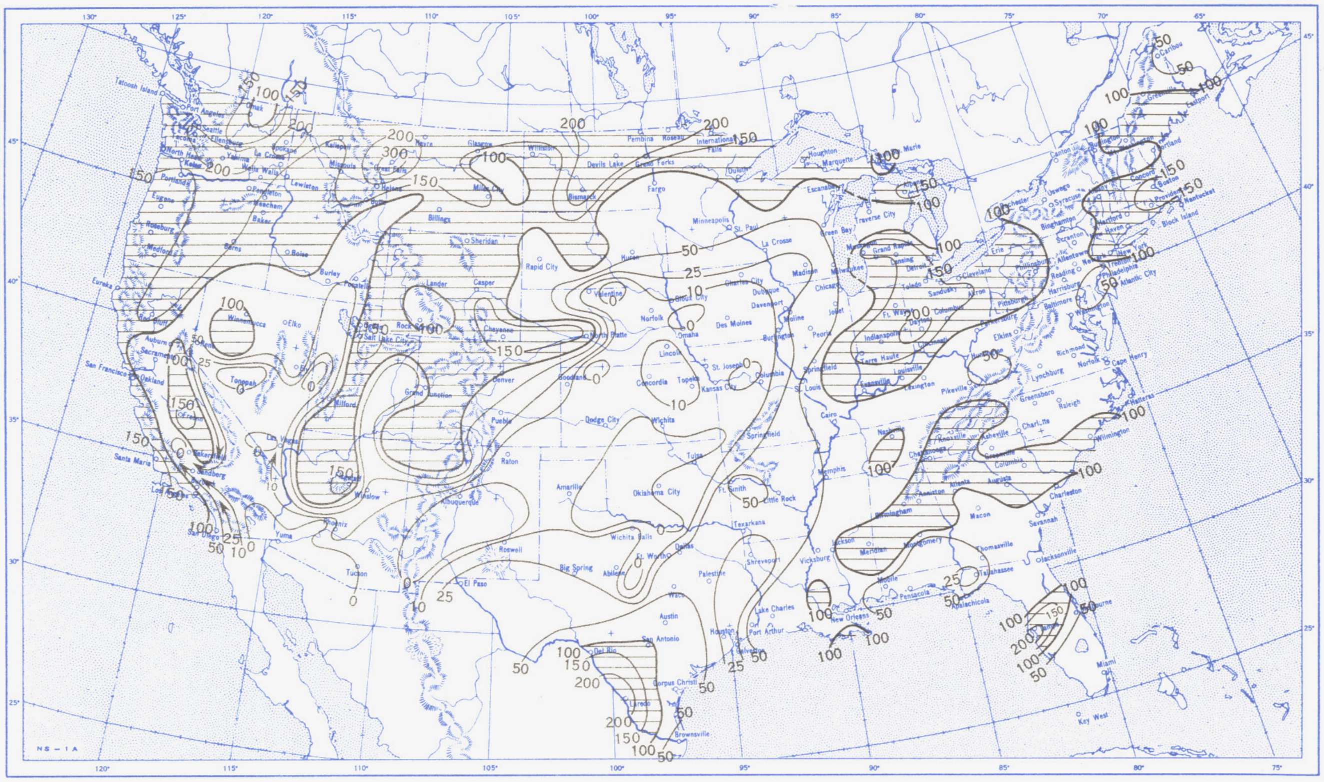
Chart II. Total Precipitation (Inches), November 1955.

Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), November 1955.

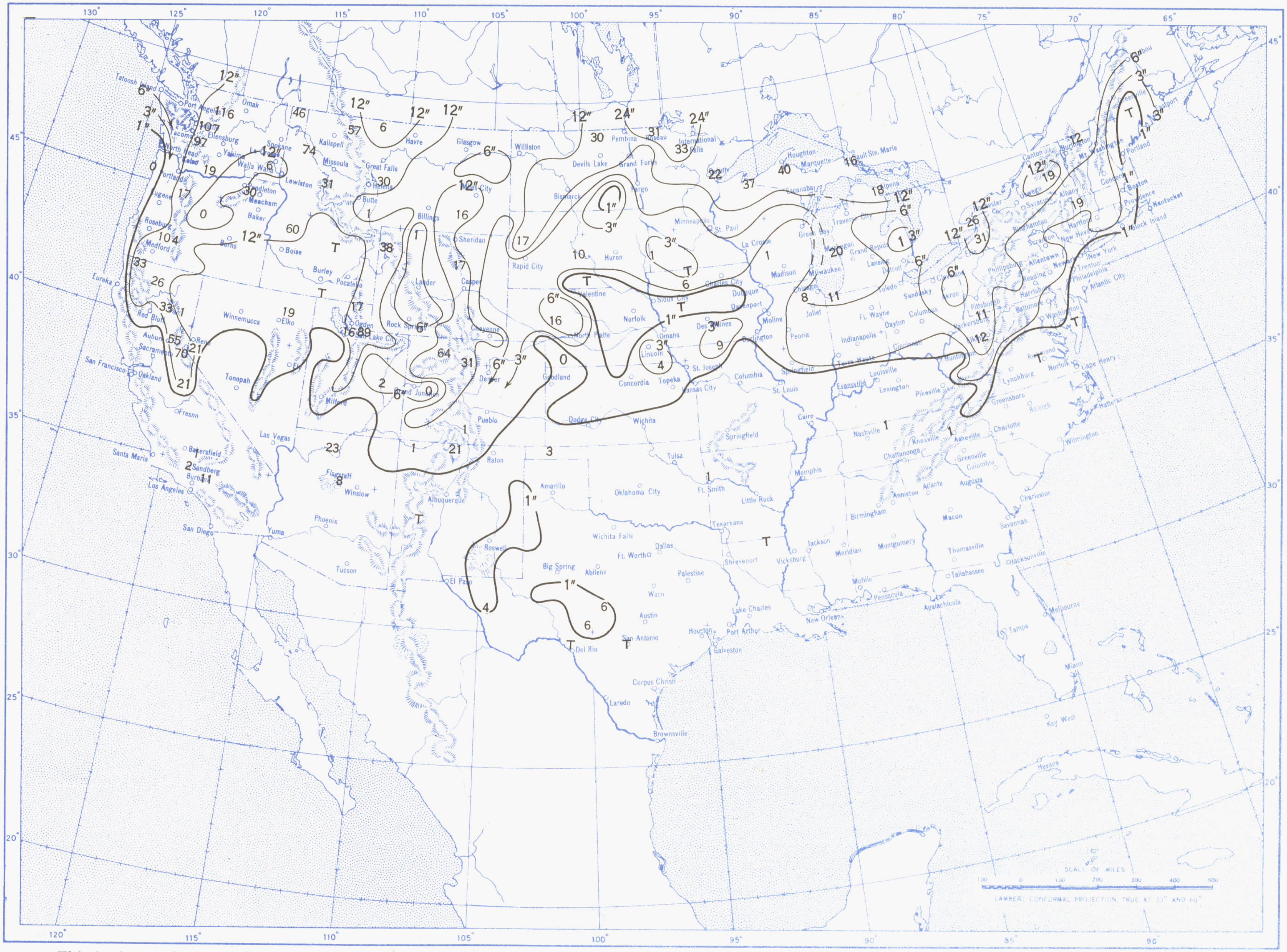


B. Percentage of Normal Precipitation, November 1955.



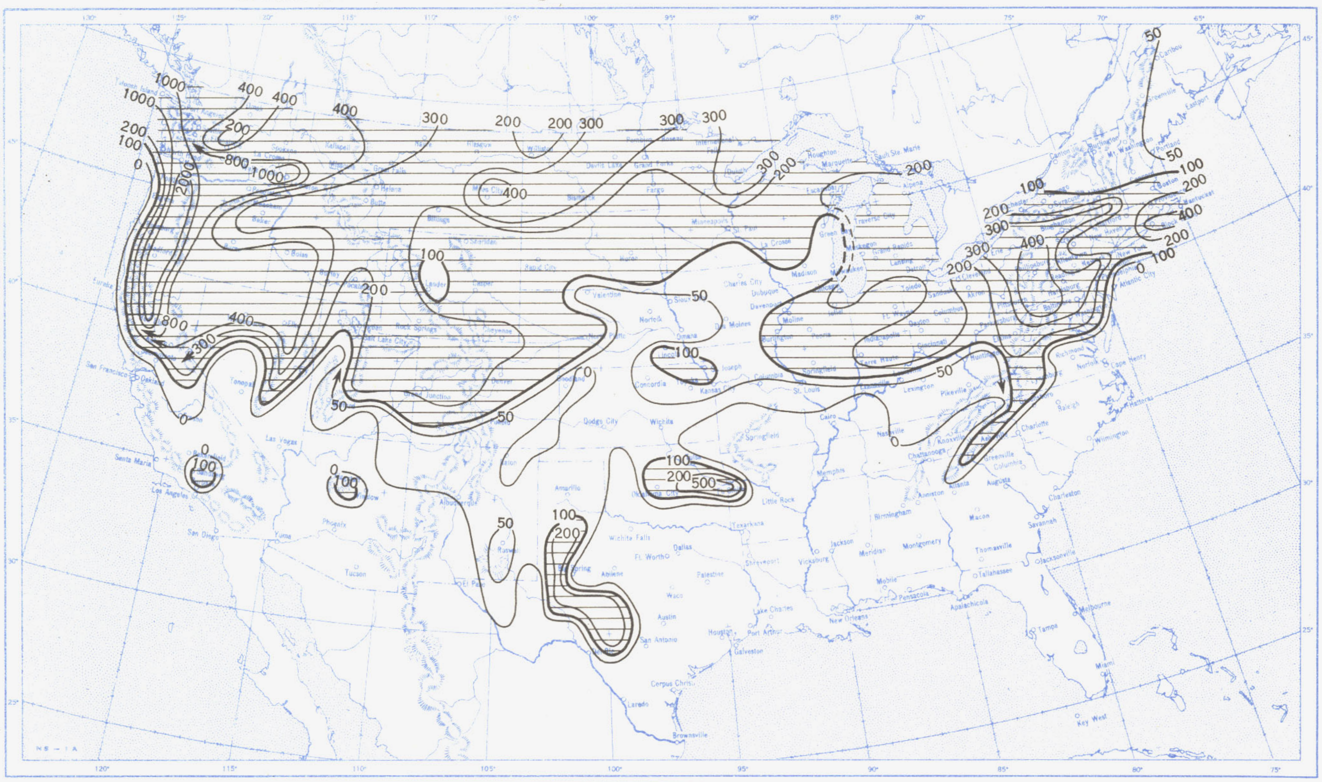
Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

Chart IV. Total Snowfall (Inches), November 1955.



This is the total of unmelted snowfall recorded during the month at Weather Bureau and cooperative stations. This chart and Chart V are published only for the months of November through April although of course there is some snow at higher elevations, particularly in the far West, earlier and later in the year.

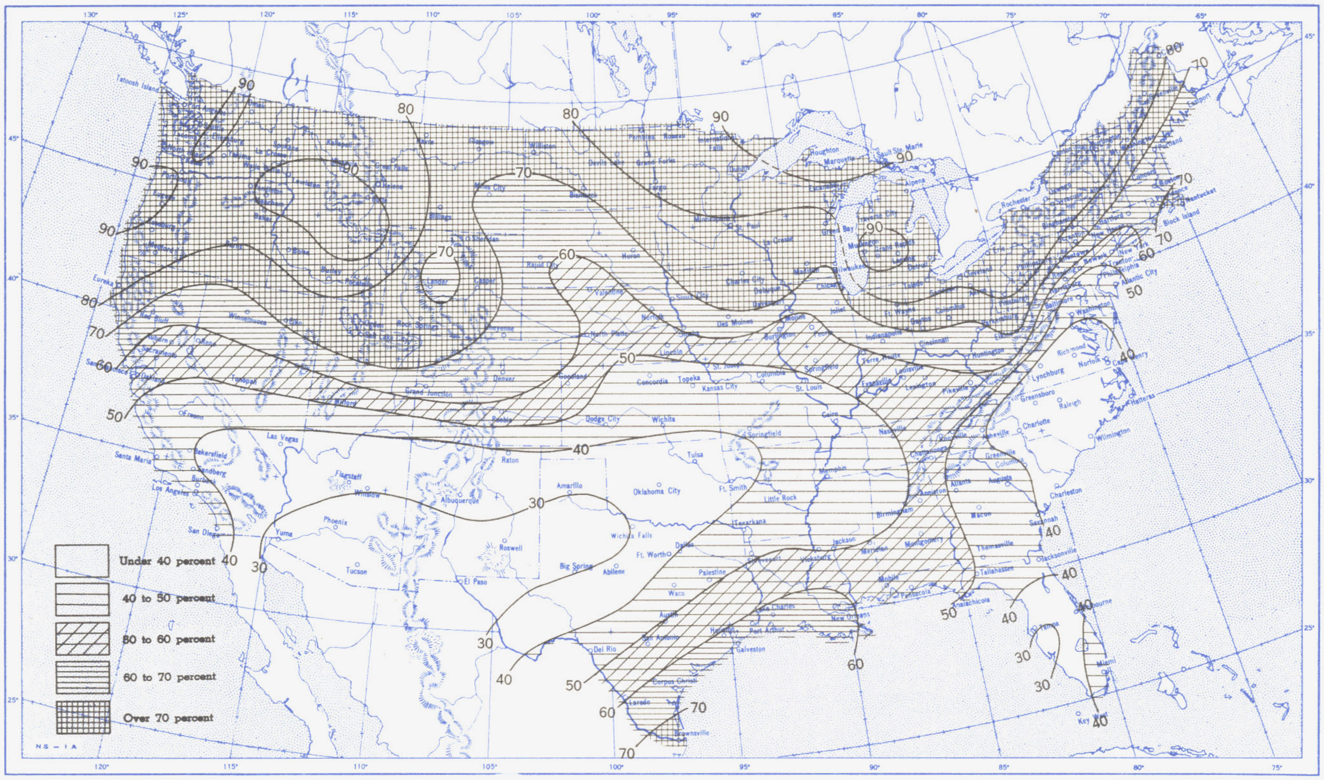
Chart V. A. Percentage of Normal Snowfall, November 1955.



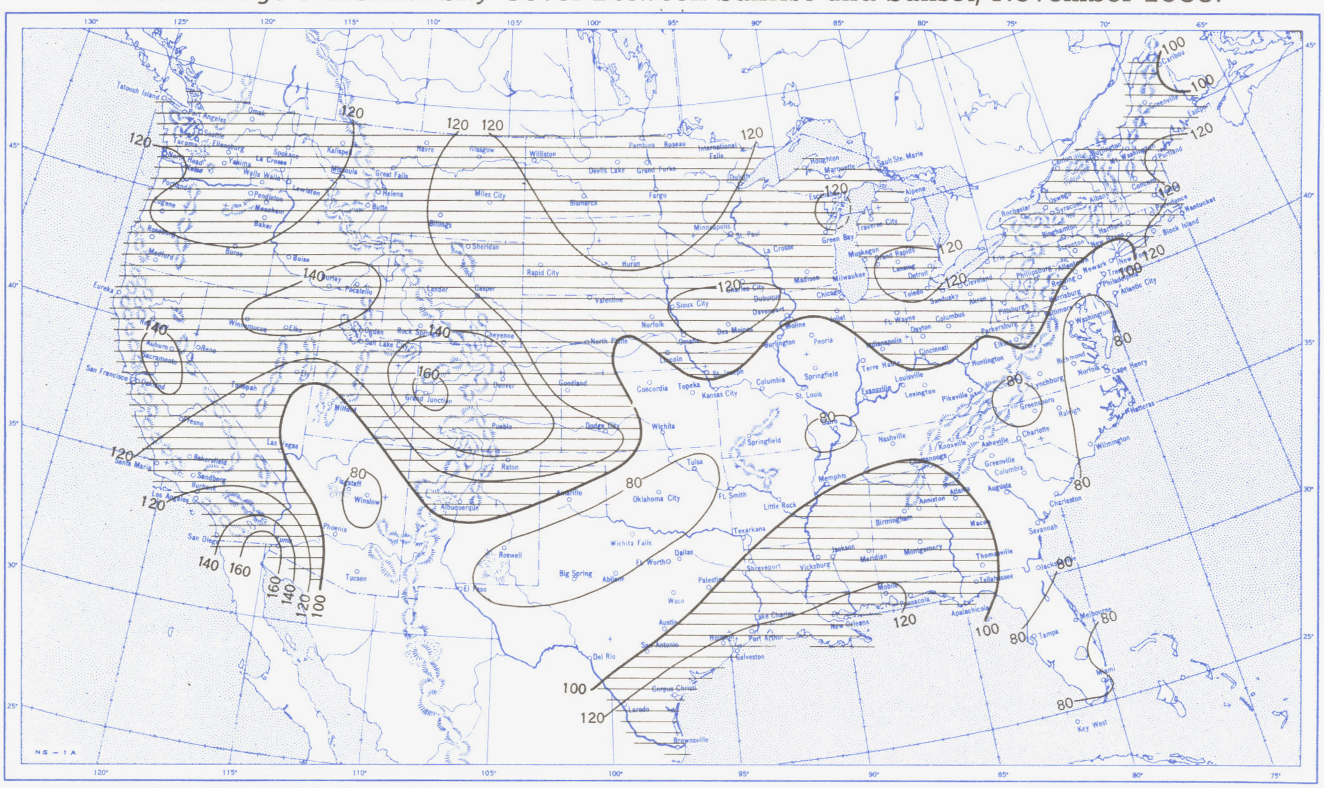
B. Depth of Snow on Ground (Inches).

A. Amount of normal monthly snowfall is computed for Weather Bureau stations having at least 10 years of record. B. Shows depth currently on ground at 7:30 a. m. E. S. T., of the Tuesday nearest the end of the month. It is based on reports from Weather Bureau and cooperative stations. Dashed line shows greatest southern extent of snowcover during month.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, November 1955.

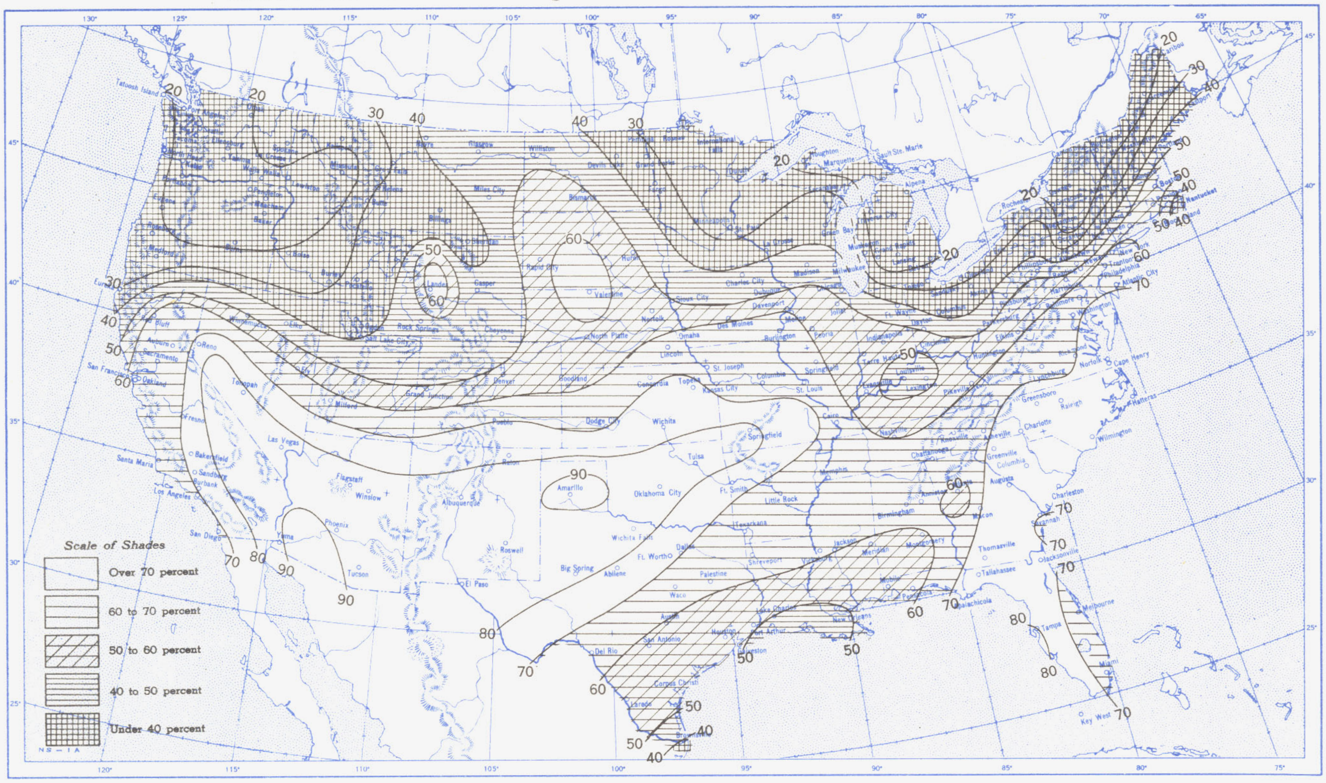


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, November 1955.

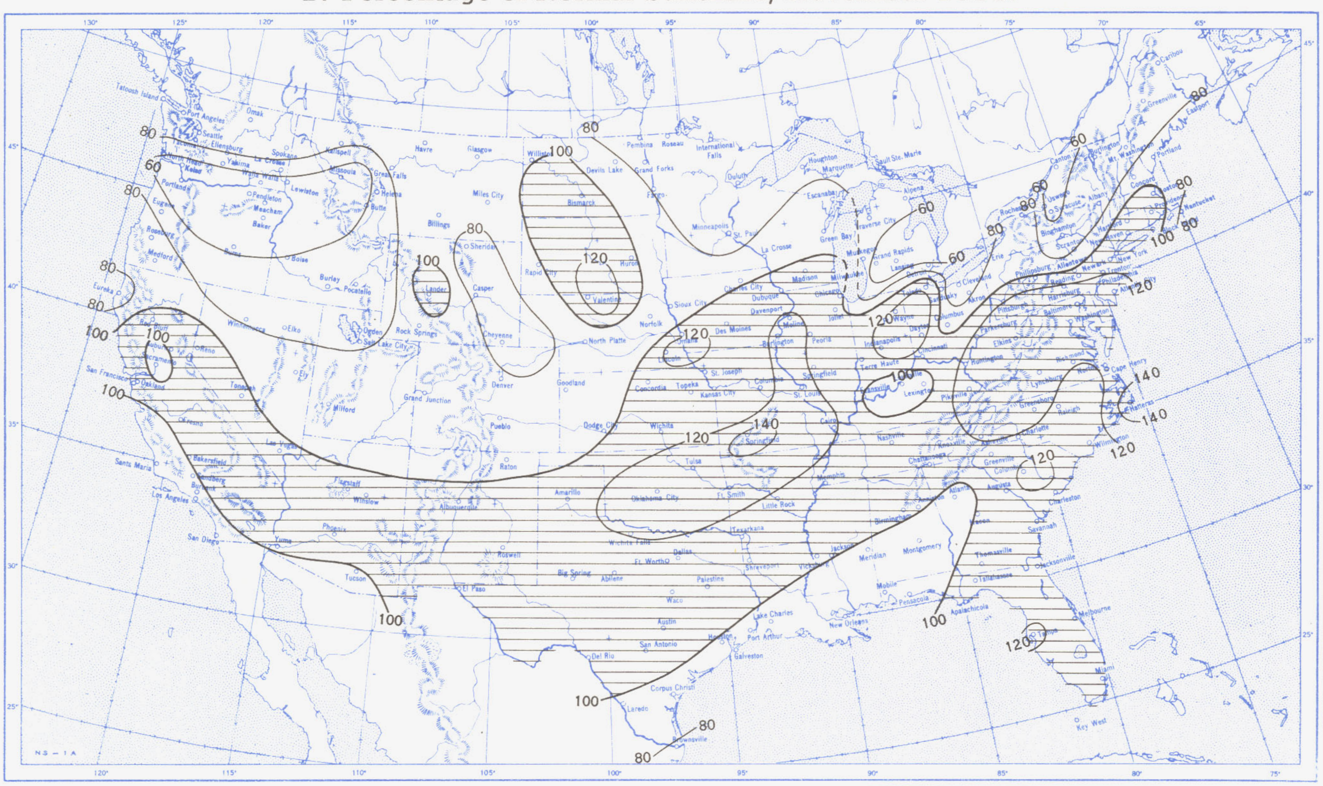


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, November 1955.



B. Percentage of Normal Sunshine, November 1955.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, November 1955. Inset: Percentage of Normal Average Daily Solar Radiation.

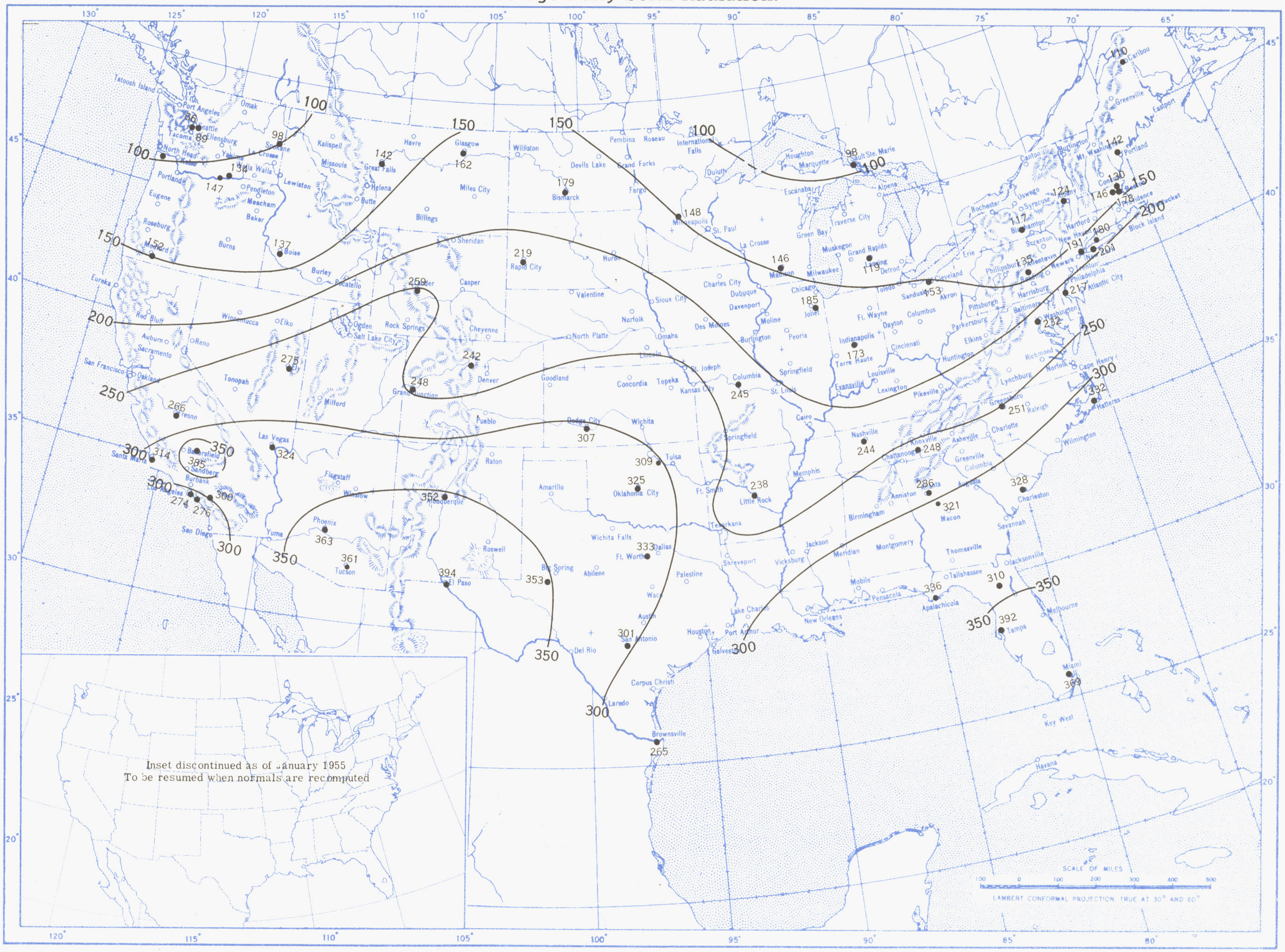
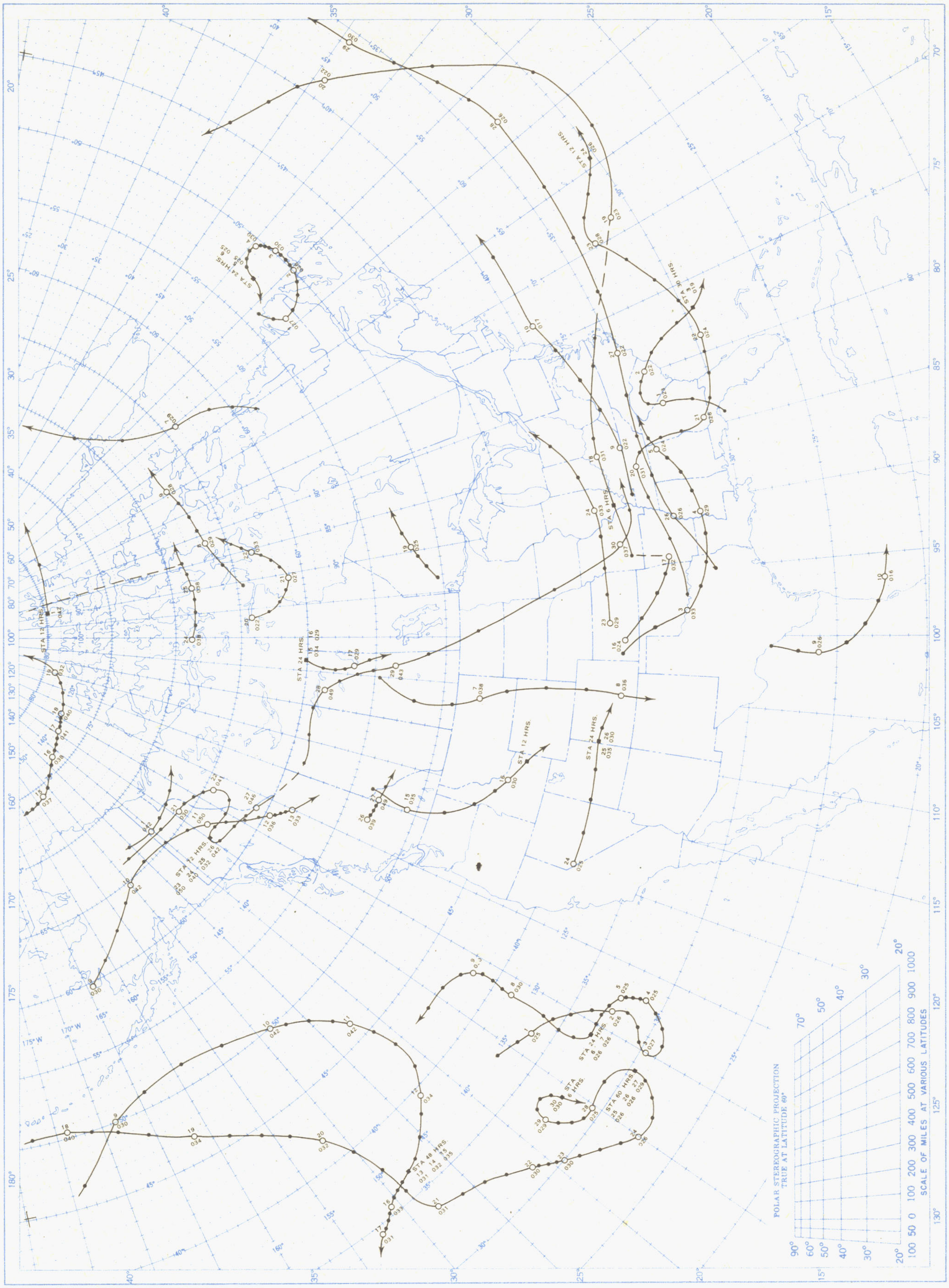


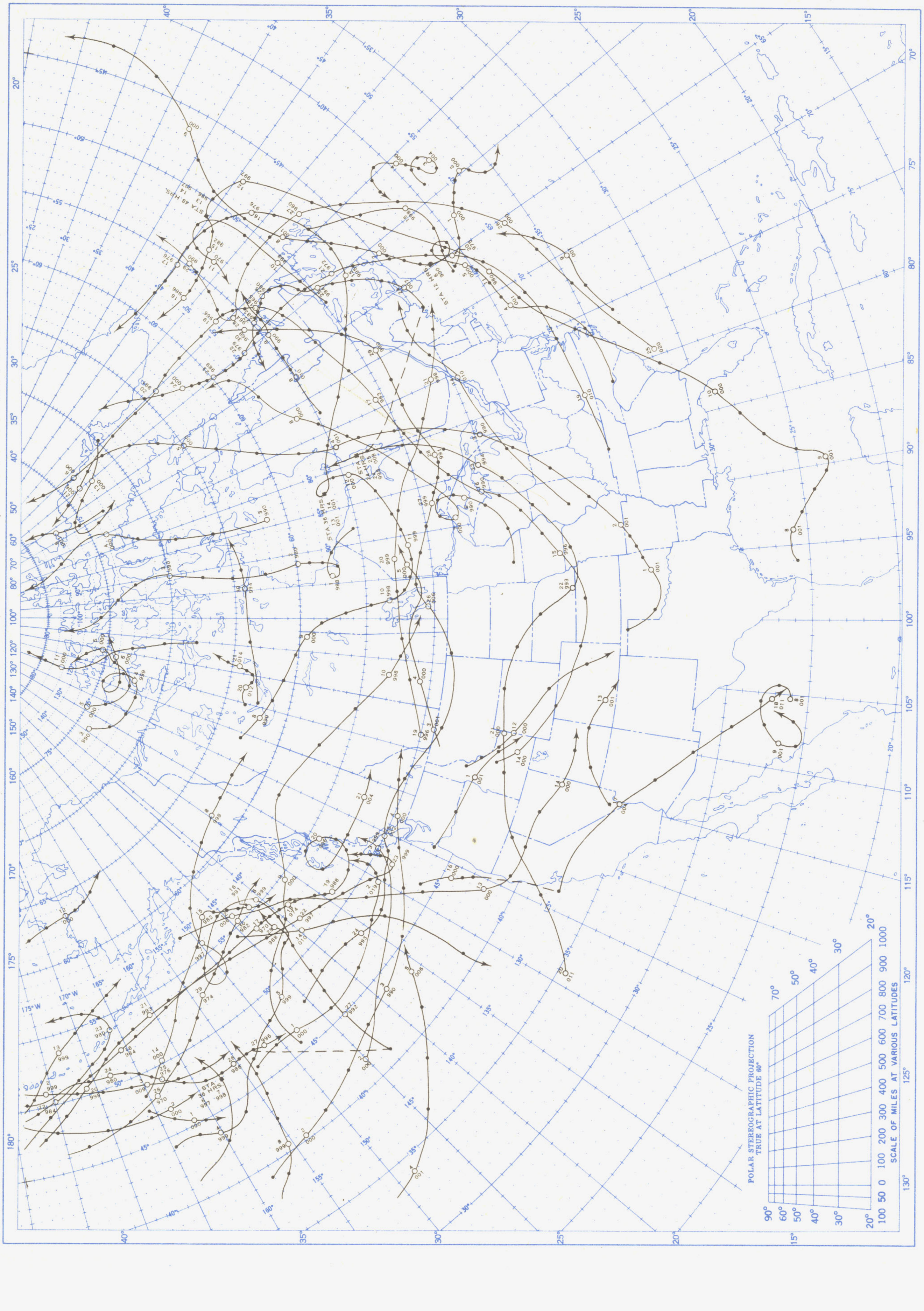
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm.$^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, November 1955. (Corrected)



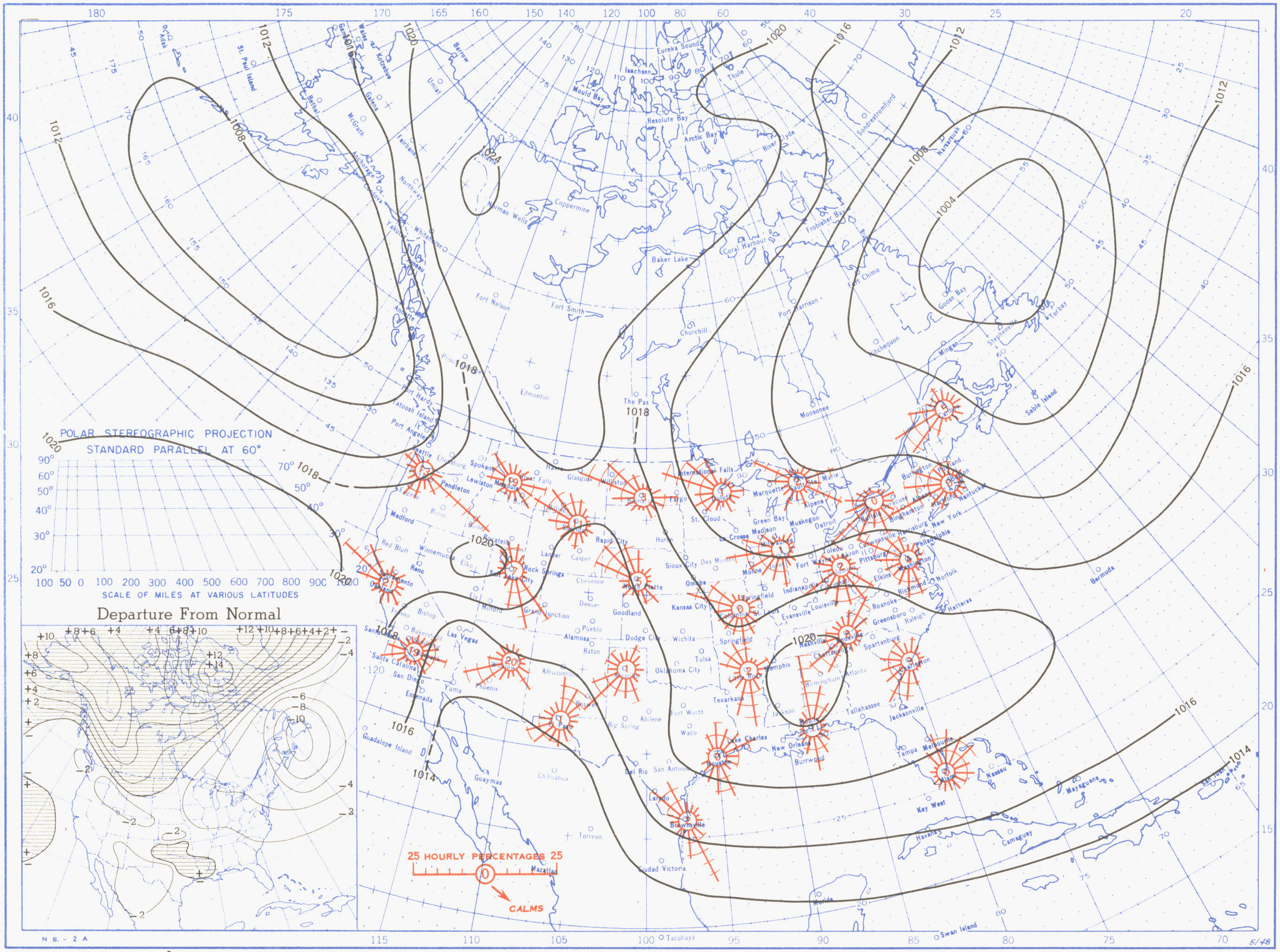
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, November 1955. (Corrected)



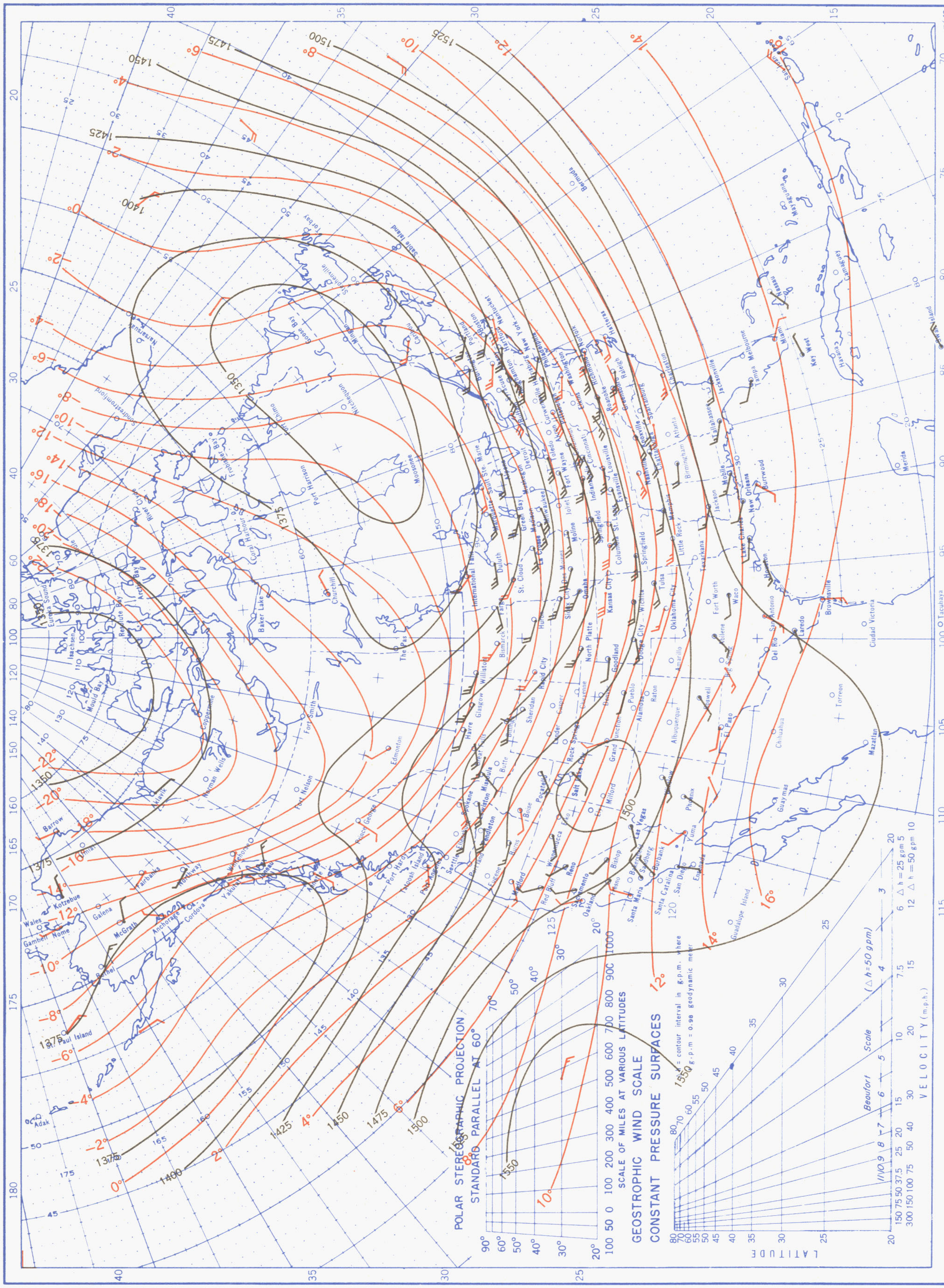
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, November 1955. Inset: Departure of Average Pressure (mb.) from Normal, November 1955.



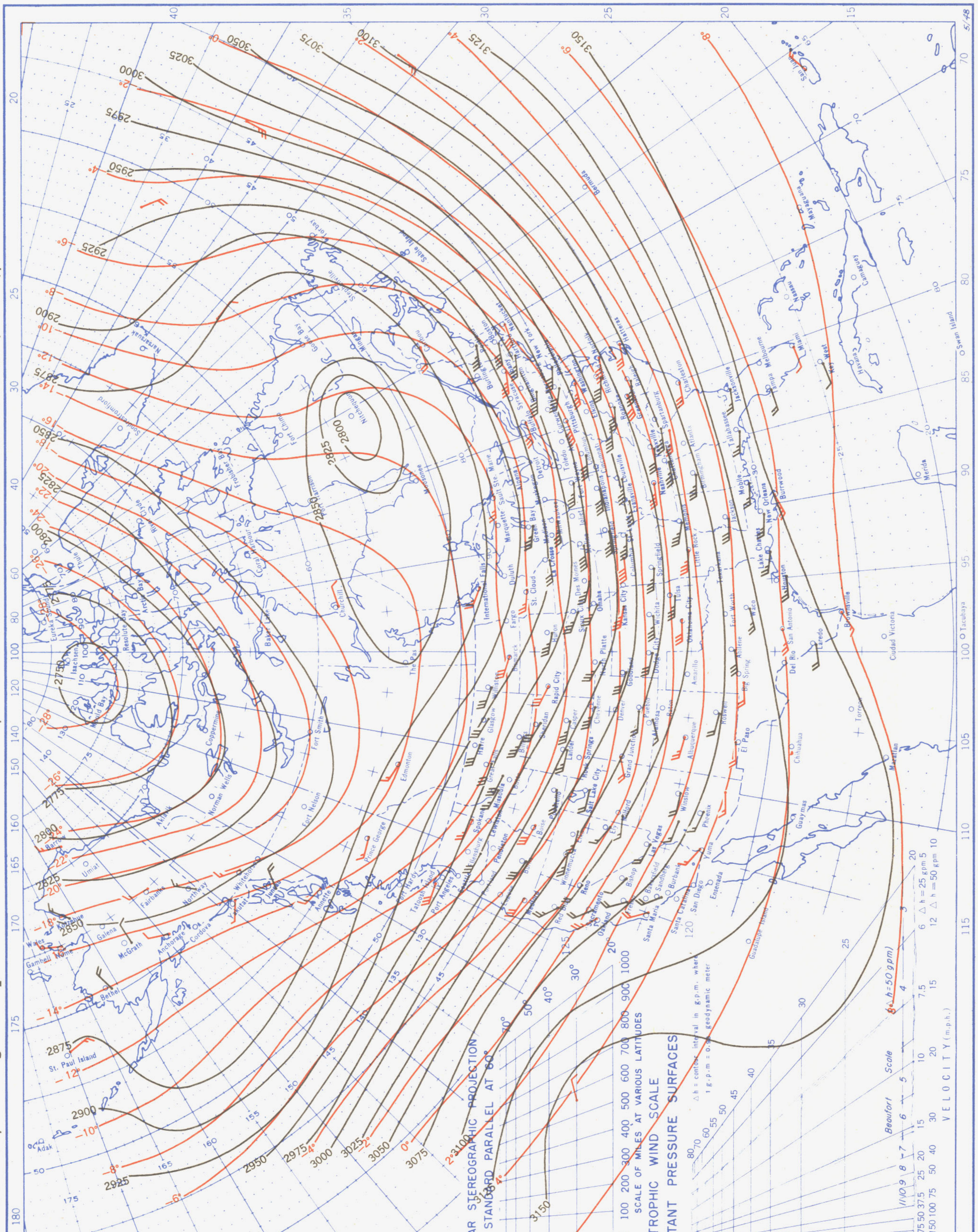
Average sea level pressures are obtained from the averages of the 7:30 a.m. and 7:30 p.m. E.S.T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), November 1955.



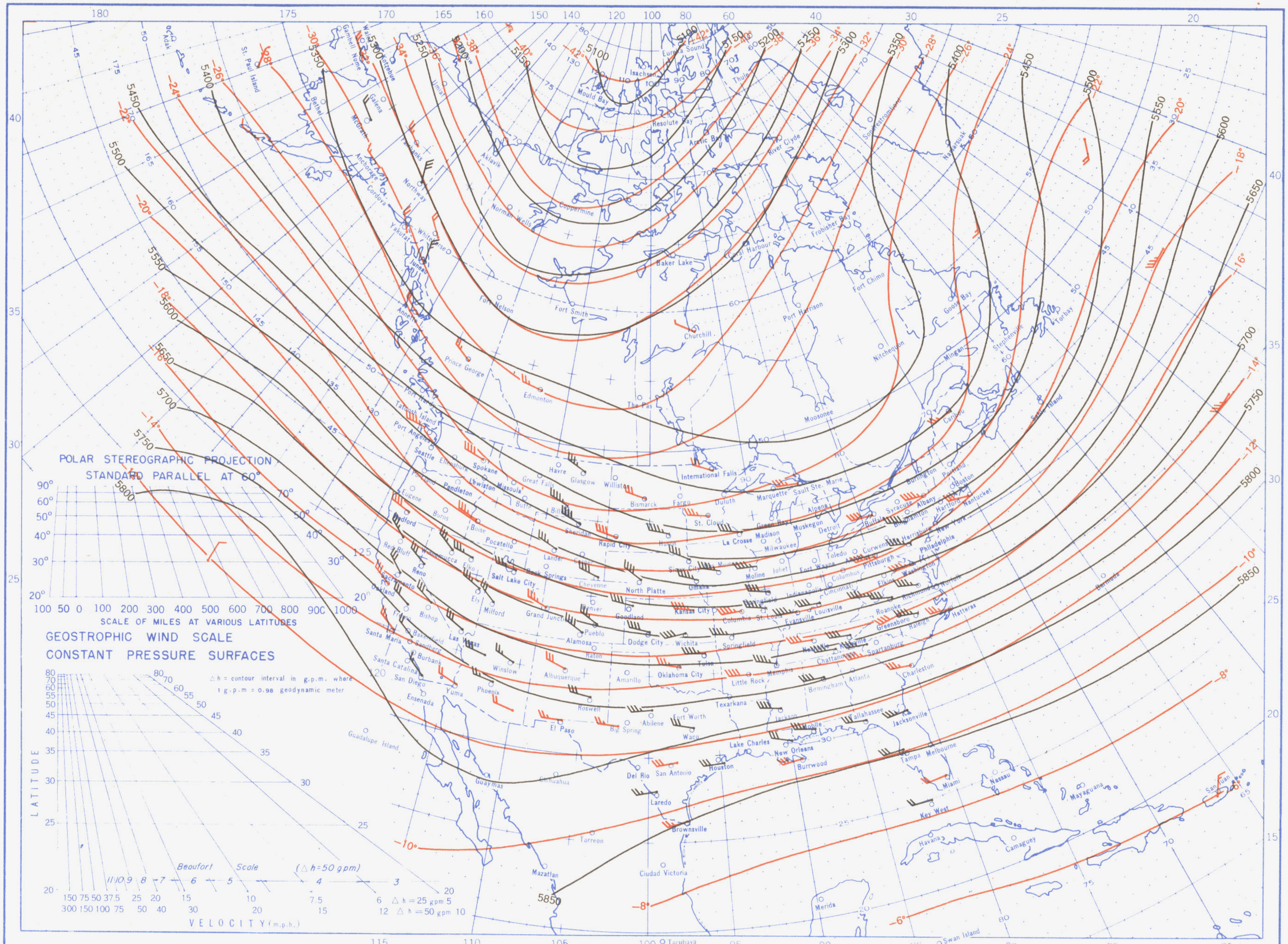
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), November 1955.



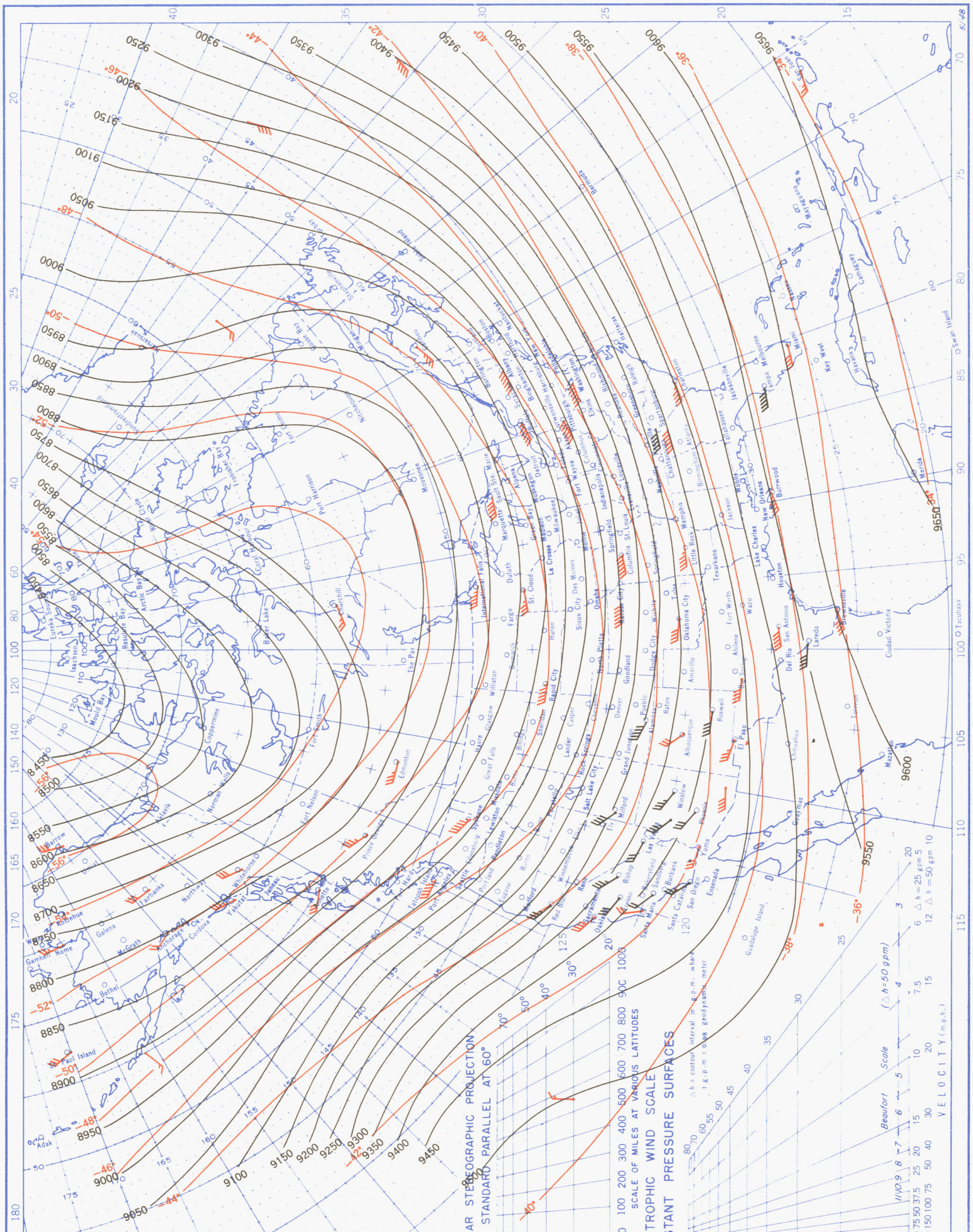
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), November 1955.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), November 1955.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.